Claims:

1. An ion implantation method for implanting ions by irradiating a semiconductor substrate with an ion beam, the ion implantation method comprising steps of:

exciting predetermined gas in a pressure-reduced chamber to generate plasma containing ions with a predetermined mass number;

forming a magnetic field along an extraction direction of the ions when the ions are extracted to the outside of the chamber; and

extracting the ions from the chamber with predetermined extraction energy.

2. An ion implantation method according to claim 1, wherein the mass number of the ions is 20 or lower.

3. An ion implantation method according to claim 1, wherein the extraction energy of the ions is 10 keV or lower.

4. An ion implantation method according to claim 1, wherein the extraction energy of the ions is 1 keV or lower.

5. An ion implantation method according to claim 1, wherein the gas is at least one selected from hydrogen gas, helium gas and boron gas.

6. An ion implantation method according to claim 1, wherein the gas is excited by arc discharge to generate the plasma.

7. An ion implantation method according to claim 1, wherein the gas is excited by a microwave to generate the plasma.

8. An ion implantation method according to claim 7, wherein the gas is hydrogen, and the hydrogen gas is excited by a microwave to generate plasma containing hydrogen molecular ions.

9. An ion implantation method according to claim 8, wherein a frequency of the microwave and intensity of the magnetic field satisfy conditions represented by one selected from the following equations:

$$\omega > \frac{eB}{2\pi m_e} \qquad (3)$$

$$\omega < \frac{eB}{2\pi m_e} \qquad (4)$$

where ω denotes a frequency of a microwave, m_e denotes electron mass, e denotes an electron charge, and B denotes intensity of a magnetic field.

10. An ion implantation method according to claim 8, wherein average stay time from the introduction of the hydrogen gas into the chamber until the extraction of the hydrogen molecular ions to the outside of the chamber is 5×10^{-4} to 5×10^{-3} seconds.

11. An ion implantation method according to claim 8, wherein for the semiconductor substrate, a Si substrate having an insulating layer thereon is used, and the Si substrate is irradiated with the hydrogen molecular ions from the insulating layer side to implant the hydrogen molecular ions at a predetermined depth of the Si substrate.

12. An ion implantation method according to claim 8, wherein for the semiconductor substrate, a Si substrate having a SiO_2 layer thereon is used, and the Si substrate is irradiated with the hydrogen molecular ions from the SiO_2 layer side to implant the hydrogen molecular ions at a predetermined depth of the Si substrate.

13. A manufacturing method of an SOI wafer, comprising:

an ion implantation step of forming a hydrogen ion implanted layer at a predetermined depth of a first wafer having an insulating layer on one surface of a Si substrate;

a lamination step of laminating a second wafer constituted of a Si substrate on the insulating layer of the first wafer after the ion implantation step, to obtain a laminated body; and

a cutting step of cutting the laminated body at the hydrogen ion implanted layer,

wherein in the ion implantation step, the hydrogen ion implanted layer is formed by the ion implantation method of claim 8.

14. An ion implantation system for implanting ions by irradiating a semiconductor substrate with an ion beam, the ion implantation system comprising:

an ion source for exciting predetermined gas in a pressure-reduced chamber to generate plasma containing ions with a predetermined mass number;

a magnet for forming a magnetic field along an extraction direction of the ions when the ions are extracted to the outside of the chamber; and

an extraction electrode for extracting the ions from the chamber with predetermined extraction energy.

15. An ion implantation system according to claim 14, wherein the ion source generates plasma containing ions with a mass number 20 or lower.

16. An ion implantation system according to claim 14, wherein the extraction electrode extracts the ions by use of extraction energy of 10 keV or lower.

17. An ion implantation system according to claim 14, wherein the magnet is a solenoid coil wound around the outside of the chamber along the ion extraction direction.

18. An ion implantation system according to claim 14, wherein the magnet is a permanent magnet disposed on an opposite side to the extraction electrode of the ion source so that one of N and S poles of the permanent magnet is arranged on a side near the extraction electrode and the other is arranged on a side far from the extraction electrode.

19. An ion implantation system according to claim 14, wherein the magnet is an electromagnet disposed on an opposite side to the extraction electrode of the ion source, the electromagnet comprising a core material made of soft steel or a magnetic substance, and a solenoid coil wound around an outer periphery of the core material in a predetermined direction.